WEEKEND/WEEKDAY OZONE OBSERVATIONS IN THE SOUTH COAST AIR BASIN

STUDY PLAN FOR PHASE I

Subcontract No's. ACI-0-29086-01 (DRI) and
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INTRODUCTION

This study plan describes the approach and rationale for the tasks that will be undertaken by investigators at Desert Research Institute (DRI) and Sonoma Technology, Inc. (STI) during Phase I of the NREL-sponsored study of elevated ozone (O_3) levels on weekends [the weekend (WE) effect] in the South Coast Air Basin (SoCAB). The goal of Phase I is to refine study hypotheses through a retrospective analyses of ambient and emissions data that are relevant to the WE effect. Five tasks are identified to accomplish these Phase I goals - two tasks for STI and three tasks for DRI. Coordination of complementary approaches and sharing of data resources will be maximized between STI and DRI, and definition of operational terms and operational criteria is currently under discussion to facilitate cross-comparison of results from individual tasks. Results of parallel efforts by the California Air Resources Board (ARB) and South Coast Air Quality Management District (SCAQMD) will be integrated with the results of Phase I. A field measurement program will be conducted in phase II to collect and assemble the air quality, meteorology and emission activity databases that are required to test our hypotheses. The assembled data will be analyzed in phase III and reconciled with our current conceptual understanding of the WE effect in the SoCAB.

The WE effect has generated strong interest because of its potential implications for ozone control strategies. Much of the difficulty in addressing the ozone problem is related to ozone's complex photochemistry in which the rate of O_3 production is a non-linear function of the mixture of reactive organic compounds (ROG) and oxides of nitrogen (NOx) in the atmosphere. Depending upon the relative concentration of ROG and NOx and the specific mix of ROG present, the rate of O_3 formation can be most sensitive to changes in ROG alone or to changes in NOx alone or to simultaneous changes in both ROG and NOx. Understanding the response of ozone levels to specific changes in ROG or NOx emissions is a fundamental prerequisite to developing a less costly and more effective ozone abatement strategies.

Since the mid 1970's it has been documented that ozone levels in the California's South Coast Air Basin are higher on weekends than on weekdays, in spite of the fact that ozone pollutant precursors are lower on weekends than on weekdays (Elkus and Wilson, 1977; Horie et al., 1979; Levitts and Chock, 1975; Zeldin et al., 1989; Blier and Winer, 1998; and Austin and Tran, 1999). Similar effects have been observed in San Francisco (Altshuler et al. 1995) and the northeastern cities of Washington D.C., Philadelphia, and New York (SAIC, 1997). While a substantial WE effect has been observed in these cities, the effect is less pronounced in Sacramento (Austin and Tran, 1999), and is often reversed in Atlanta (Walker, 1993) where ROG/NOx ratios are typically higher. Several other of the above studies show that the WE effect is generally less pronounced in downwind locations where ambient ROG/NOx ratios are higher.

In past air quality modeling performed in Southern California and elsewhere, the measured ambient ROG/NOx ratios were substantially higher than the corresponding ratios derived from the modeling inventory. Such discrepancies may have important implications for model predictions of the consequence of ROG versus NOx controls. With the questions that still remain regarding the accuracy of emission inventories, the WE effect emphasizes the need for observation-based data analysis to examine the relationship between ambient O_3 and precursor emissions. Although the natural experiment of varying emissions that occurs between weekday and weekends provides an interesting test case for air quality simulation models, their performance and evaluation must be accompanied by an evaluation of the accuracy of the temporal and spatial patterns of precursor emissions.

Preliminary Conceptual Explanation of the WE effect

The observed WE effect in the South Coast Air Basin arises from differences in absolute emissions of ozone precursors and ozone forming potential due to day-of-the-week changes in ROG and NOx emissions. Variations in meteorology affect the magnitude and spatial extent of the WE effect within the basin. The time-variations in the ROG/NOx ratio and the resulting effect on the rate of ozone formation appear to be a key factor in the magnitude and spatial extent of the WE effect. The relative behavior of ROGs and NOx in ozone formation can be understood in terms of competition for the hydroxyl radical (OH). When the instantaneous ROG-to-NO_2 ratio is less than about 5.5:1, OH reacts predominantly with NO_2, removing radicals and retarding O_3 formation. Under these conditions, a decrease in NOx concentration favors O_3 formation. At a sufficiently low concentration of NOx, or a sufficiently high ROG-to NO_2 ratio, a further decrease in NOx favor peroxy-peroxy reactions, which retard O_3 formation by removing free radicals from the system. At a given level of ROG, there exists a NOx mixing ratio, at which a maximum amount of ozone is produced, an optimum ROG/NOx ratio. For ratios less than this optimum ratio, increasing NOx decreases ozone. This situation occurs more commonly in urban centers and is the case for most of the central SoCAB.

An increase in the intensity of the WE effect has occurred during a period that has seen steadily decreasing ambient 6-9 a.m. ROG/NOx ratios in the SoCAB. For example, the summertime 6-9 a.m. ROG/NOx ratio in much of the SoCAB was 9.5 during the 1987 Southern California Ozone Study (Fujita et al., 1992). By 1992, this ratio had declined to close to 6.0 (Stoeckenius et al., 1995). If this trend continued into the late 1990's, the morning ambient ROG/NOx in the source regions of the SoCAB would be low enough to significantly retard the formation of O_3. Although NOx and ROG levels are both lower on weekends, available data show that the decrease is relatively greater for NOx, which results in higher ROG/NOx ratios on weekend mornings relative to weekdays. The greater ROG/NOx ratios increase the rate of ozone formation on weekends and apparently increase O_3 levels on weekends versus weekday despite the overall lower level of ozone precursors.

The increased vertical mixing and horizontal advection (i.e., inland penetration of the marine layer) that occurs in the afternoon may moderate the effect of the increased rate of ozone formation. The magnitude and spatial extent of the WE effect may be a function of the amount of time available for ozone formation to proceed before ventilation occurs and the rate at which ROG/NOx ratios increase (due to more rapid removal of NOx versus ROG) as emissions are transported to the eastern side of the Basin. This reaction time is less near the coast and increases inland to the east. Thus the WE effect is less pronounced in downwind area of the Basin because of the longer time for ozone formation and higher ROG/NOx ratios that favor more rapid formation of ozone. The WE effect is greatest where the ozone formation is more ROG-limited during the weekday and more NOx-limited during the weekends, and ventilation occurs before the potential maximum ozone level is produced.

Preliminary Hypotheses

Each of the following hypotheses is assigned one of the following confidence levels based on the probability that additional experimental data will achieve a definitive conclusion.

- High confidence: There is low uncertainty in the data or data analysis approach or the conclusion can be supported by more than one independent analysis approach, each of which has moderate uncertainty.

- Medium confidence: There is moderate uncertainty in the data or data analysis approach and independent analysis approaches will not be available.

- Low confidence: There is large uncertainty in the data or data analysis approach and independent analysis approaches will not be applied

1. Ozone formation in SoCAB, particularly the western and central portions of the basin, is ROG-sensitive with respect to ozone formation. ROG/NOx ratios are higher on weekends than on weekdays due to changes in emissions, resulting in greater weekend ozone forming potential despite lower [ROG] and [NOx] on weekends. The WE effect is greater where $\Delta[O_3]_{max}/\Delta[ROG]$ is greater during weekdays than during weekend days. The WE effect is most pronounced in area of the basin with the greatest NOx disbenefit (i.e., most ROG-limited on weekdays). (HIGH)

2. The magnitude of the WE effect is a function of the ozone forming potential and the time available for ozone formation before dilution offsets ozone formation. (HIGH)

3. The WE effect is less pronounced in the eastern portion of the SoCAB where WE/WD differences in ROG and NOx emissions are masked by emission transport. Transport causes higher ROG/NOx ratios due to more rapid removal of NOx versus ROG as the emissions are transported toward the eastern side of the Basin. (HIGH)

4. Overnight carry-over of ozone, ROG and NOx from Friday and Saturday nights is greater than during other days of the week. Increased carryover is greater for ROG than for NOx. This affects the ozone forming potential of the ambient air. (HIGH)

5. A number of changes in emissions by day-of-week, time-of-day, and by location in the SoCAB can be postulated. Table 1 provides a summary of postulated changes in emissions-related activities between weekdays and weekend days. The table shows our hypotheses for the changes in time and space for each of the major categories and pollutants. The postulated emission changes, in order of the row in which they appear in Table 1, are assigned a confidence of MEDIUM, HIGH, MEDIUM, HIGH, and MEDIUM, respectively.

Table 1
Postulated emission changes on weekend days, versus weekdays, in the SoCAB

Emission Source	Spatial Pattern	Diurnal Pattern	Daily Total Emissions	Probability of Success
All Sources	Spread out	Spread out	Lower	MEDIUM
Stationary Sources	Lower in CBD [a]	Spread out	Mixed	HIGH
Area-wide Sources	Higher in suburbs	Higher in afternoon	Higher	MEDIUM
On-Road Mobile	Spread out	Spread out	Lower	HIGH
Gasoline Vehicles	Higher in Suburbs	Lower in AM	Lower	
Diesel Vehicles	Lower in CBD	Spread out	Lower	
Other Mobile	Spread out	Spread out	Mixed	MEDIUM
Industrial	Lower in CBD	Spread out	Lower	
Recreational	Higher in Suburbs	Higher in afternoon	Higher	
Misc. (Trains & buses etc.)	Lower in CBD	Spread out	Lower	

a. CBD is the central business district, i.e. downtown Los Angeles and the surrounding area of highest weekday emissions and commerce.

6. Because the contribution from each source category vary by pollutant and because the directional emission changes are not correlated, the emission changes postulated in Table 1 are difficult to verify. In the real world, it is difficult to conduct a true scientific experiment where only one variable is changed while all others are held constant. Therefore, in formulating our hypotheses, we have combined the expected emission changes into what we believe are independently verifiable and quantifiable impacts. Specific emissions changes on weekends may include the following:

- Increased refueling of gasoline-fueled vehicles (including Friday). (MEDIUM)
- Decreased number of trips of gasoline-fueled vehicles. (MEDIUM)
- Increased home-related activity (e.g., lawn and garden equipment, surface coatings, paints, backyard barbecues, etc.). (LOW)
- Decreased commercial-related activity (e.g., lawn and garden equipment, surface coatings, paints, etc.). (LOW)
- Increased recreational activities (boating and other off-road mobile sources). (MEDIUM)
- Decreased industrial activity. (MEDIUM)
- Decreased diesel (truck, bus, and train) activity. (HIGH)
- Decreased commuter activity (shifts time and location of on-road mobile source emissions). (MEDIUM)

- Increased use of utility vehicles for personal use. (MEDIUM)

- Decreased trip chaining. (MEDIUM)

7. Because each of the activities listed emits different hydrocarbons, it should be possible to trace these expected changes with ambient data as well as to estimate the changes through surveys. Table 2 summarizes the major emissions hypotheses to be tested in this study and includes a brief explanation of probable cause and methods to verify and quantify the effects. The postulated emission changes, in order of the row in which they appear in Table 2, are assigned a confidence of HIGH, HIGH, MEDIUM, and LOW, respectively, according to our estimate of the probability that additional experimental data will achieve a definitive conclusion.

Table 2
Emission Change Hypotheses on Weekend Days, Versus Weekdays

Emissions Change	Location	Timing	Source Changes	Test Method(s)	Probability of Success
ROG/NO_x higher	CBD	AM	Lower NO_x (diesel Vehicles and industry)	Activity Survey Ambient Data in CBD	HIGH
NO_x lower	CBD	All day	Decreased activity (stationary and mobile)	Activity Survey Ambient Data in CBD	HIGH
ROG higher	Suburbs	PM	Increased activity (area-wide and mobile)	Activity Survey Ambient Data in suburbs	MEDIUM
ROG reactivity	Suburbs	PM	Decrease in industrial solvent use	Activity Survey Ambient Data in CBD	LOW

Objectives

The overall objectives of Phase I are as follows:

- To acquire emissions activity data, meteorological data, and air quality data and to perform sufficient analysis of these data to establish data needs and priorities for Phase II field study data acquisition and measurements.

- To refine hypotheses for further testing in Phases II and III.

STUDY PLAN

This section describes the approach and methods that will be used during Phase I of the study. Task statements are in *italics* and an explanation of rationale and approach are in regular text.

Task A - Review of Available Emissions Data (STI Task 1)

A1. Based on available emission inventory data, identify ROG and NOx sources with the potential to be different on weekends than on weekdays.

A2. Summarize the diurnal variations in daily ROG and NOx emissions by day-of-the-week for these sources.

A3. Review the method(s) used to determine temporal variations and evaluate uncertainties and identify alternative methods or additional data that are available to update and improve existing temporal allocation of ROG and NOx emissions.

A4. Work with ARB and the SCAQMD to ensure that we minimize duplication of effort and that the most effective data acquisition and analysis approaches are taken.

Some of the preliminary hypotheses include (1) reduced NOx emissions on weekends due to a decrease in truck traffic, (2) weekend-weekday patterns that differ diurnally or geographically (such as increased use of lawn/garden or recreational equipment, or decreased use of industrial solvents on weekends), (3) potential carryover of aged emissions from the previous day (from peak in traffic volume on Friday). In this task, STI will expand the preliminary list of hypotheses presented in this proposal and will provide a priority listing of hypotheses for further study. In order to formulate and rank these hypotheses, STI will review literature, hold internal and external discussions with experts (such as transportation planning agencies), and make preliminary contacts with alternate sources of data (such as business leaders).

In order to rank further study efforts, STI will consider (1) the potential impact of the emissions change on ozone formation and (2) the feasibility of gathering adequate data to refute or to support each hypothesis in a meaningful way. Using the ranked listing of hypotheses, we will prepare a list of data gathering and analysis tasks required to test each hypothesis. Data needs will be cross-checked against available data and data gaps will be identified. The feasibility of filling any important data gaps will be investigated.

Depending on the available data, some hypotheses may be subjected to some preliminary testing in this task. However, the primary objective of this first phase effort is to provide a roadmap or plan of action items to collect and compile new information about emissions-related activity patterns in the SoCAB. The plan of action will be carried out during Phase II.

Task B - Retrospective Analysis of Ozone, Ozone Precursors and Ozone Episodes (DRI Task 1)

B1. Assemble an air quality database including the species O_3, CO, total NMHC, and NOx, for all SoCAB routine monitoring sites from years 1980-99. To the maximum extent possible, find and use data from the California Air Resources Board Aerometric Data Analysis and Management (ADAM) system which has also been validated by other efforts. Where available, total NMHC data will be collected for this period. Where possible, a linear regression of the total hydrocarbons (THC) measurement or similar treatment will be used to obtain NMHC, as these methods have been shown to be more accurate (Fujita et al., 1995). PAMS data will be assembled for 1995-99. Information for PM_{10}, $PM_{2.5}$, visibility, and b_{scat} is also included in this database where available.

B2. Assemble a meteorological database for key sites in the SoCAB and surrounding areas from years 1980-99. These key sites are chosen to characterize synoptic and mesoscale patterns dominating SoCAB weather with particular attention on defining the speed and direction of the coastal sea breeze and the timing and extent of inland intrusion of marine air. Candidate sites include surface monitoring sites operated by the SCAQMD, National Weather Service (NWS) surface airways observation (SAO) and upper air radiosonde observation (RAOB) sites, and Remote Automated Weather Station (RAWS) and California Irrigation Management Information Service (CIMIS) surface sites. Parameters include wind speed (WS), wind direction (WD), and ambient temperature (Ta) from all selected surface sites, with humidity and visibility (or other measure of coastal overcast) also included where available. Parameters from upper air sites include WS, WD, Ta, humidity, and pressure. To the maximum extent possible, we will use data that have been validated by other efforts.

B3. Analyze spatial, temporal and statistical distribution of ozone and other species. Generate concentration contour-maps, plot time series, and generate box & whisker plots and histograms of O_3, CO, total NMHC, NOx, (O_3+NOx), and other combinations of pollutants at selected locations. Contour maps are prepared as a daily maximum and for each composite hour of interest for each weekday and for three other important weekday groupings – [Tuesday, Wednesday, Thursday], [Monday - Friday], [Saturday & Sunday]. The holidays of Memorial Day weekend, 4^{th} of July (and its possible weekend occurrence), and Labor Day weekend will also be considered. Contour plots help characterize the spatial variations in magnitude of the WE effect. Base maps of the SoCAB for the contour plots will be prepared using the geographic information system (GIS) software package, ArcView® (Environmental Systems Research Institute, Inc.). DRI investigators will look for obvious differences in spatial pattern and time-evolution among the all seven weekdays and the three additional weekday groups. Inspection of time series is conducted to relate magnitude and timing of ozone peaks on weekdays and weekends to the downwind distance from the coast. Box and whisker plots and histograms display the variability and statistical distribution of pollutant concentrations. Two-dimensional ozone times series (2DOTS)[1] plots of entire ozone seasons of interest (e.g., 1997) are generated where hourly values are represented by color across 24 "hourly" columns and 184 "season day" rows. Statistical treatment includes grouping by year and by the groups of years used by ARB in

[1] While 2DOTS plots are 2D in time, they are overall 3D plots due to the color representation of ozone concentration.

their WE/WD analyses. These straight-forward analyses serve to guide DRI and STI investigators in identifying episodes of interest and choosing and applying more sophisticated statistical measures for the rest of this task; they also provide corroboration of emission inventory results from Task A. In addition, the results for each year are compared to ARB results from groups of years to better examine inter-annual variability and emissions reductions.

B4. Analyze WE/WD changes in ozone at each site. Define a parameter for average WE/WD difference at a site as $DO_{3i,j,k} = <O_{3i,k}>-<O_{3j,k}>$, where the brackets denote an average over a specified time period (default of one ozone season), *i* represents a weekend day or weekend group of interest but could range over all days, *j* represents a weekday or weekday group of interest but could range over all days for $i \neq j$, and *k* denotes the site. For example, *i* could be Friday, Saturday, Sunday and Monday as "weekend" days, and j could be Tuesday, Wednesday, Thursday, or the average of [Tuesday, Wednesday, Thursday] to represent the typical "weekday". (Hereafter, $DO_{3i,j,k}$ is referred to simply as DO_3 with the understanding that the subscripts apply whenever of interest.) Statistical examination of the uncertainties will be performed to establish the significance of the results and to assure that averaging does not mask effects or change the significance or an inter-comparison. Map the spatial distribution of DO_3 with contours superimposed on a map of the SoCAB. Also compute this average quantity for other pollutants: *DNO*, *DNOx*, $D(O_3+NOx)$, *D(total NMHC)*, *DCO* and other combinations of pollutants and map these contours. By inspection of DO_3 contour maps, DRI investigators can determine differences in spatial distribution of maximum concentration and maximum WE effect for later comparison to the conceptual model.

B5. Perform Fourier transforms of surface O_3, NOx, CO, and total NMHC for several selected sites possessing the most complete records during years 1980-99. The power versus frequency spectrum should distinguish between half-day, daily, and weekly cycles. The relative strength of the weekly cycle is a measure of the strength of the WE effect. This strength is contour-mapped to determine spatial distribution in the SoCAB. Results are compared to the ΔO_3, ΔNO, ΔNOx, $\Delta(O_3$+NOx), ΔCO analysis from task B4 to determine if sites with largest weekly cycle compare to largest ΔO_3. Pre-reformulated gasoline years will be compared to post-reformulated gasoline years. This method provides a check on the DO_3 analyses in subtask B4 to find sites with the greatest WE effect; the two treatments should give similar results. Previous Fourier transform results of hourly data from the COAST study in Texas indicate high probability of meaningful results, even for 3-hour integrated canister samples.

B6. Adopt criteria for air quality classification and meteorological classification of study days. Air quality criteria should provide a minimum of three groups, e.g., "high", "medium" and "low" ozone days, identified by patterns of 1hr and 8hr ozone standard exceedances. Assign a category to each day during ozone seasons 1980-99. Meteorological classification should provide a minimum of two groups, e.g., an "ozone day" and a "non-ozone" day. However, we expect to use previous analyses (e.g., the CART analyses performed by the SCAQMD or the soon to be completed analysis by ENVIRON for STI) to obtain more than two evaluated meteorological categories with ozone impacts. Assign a category to each day during ozone seasons 1980-99. Use the air quality database to test the errors of omission and commission for these meteorological categories to evaluate the results of subtask B7. Quantify the number of candidate days that are removed from each season when these classifications are employed, and estimate the effect on the bulk and annual statistics. This classification permits the efficient inclusion or exclusion, based on meteorology, of days for the refined analyses (subtask B7).

B7. Refine spatial, temporal and statistical analysis to include meteorological effects. Repeat contour-map, time series, box and whisker plot, and histogram analyses for the high-ozone classification(s) of interest to factor in meteorological effects. Three approaches are used: 1) generation of bulk statistics for all days with the assumption that meteorological variability will average out (from subtask B3); 2) generation of bulk statistics for episode days and non-episode days (or more detailed classifications from subtask 3.1.6); and 3) identification of weekend ozone episodes during which significant meteorological changes have occurred, and removal of these episode days before statistical analysis. Generation of an operational definition of significant meteorological changes will be included in this task. It is anticipated that this step will reduce “noise” from the overall WE/WD signal by deleting synoptic conditions that do not foster generation of ozone. Include in this re-analysis the weekday and weekday groupings, for example, examination of $\Delta[O_{3Friday} - O_{3Saturday}]$, $\Delta[O_{3Saturday} - O_{3Sunday}]$, and $\Delta[O_{3Sunday} - O_{3Monday}]$ for each site where changes due primarily due to meteorology have been eliminated. Reconcile results with the hypotheses and conceptual model. This quantification of the WE effect has not been previously performed and may increase our understanding of the changes in emissions inventory by reducing meteorological effects.

B8. Create empirical EKMA plots from PAMS site data. The EKMA plots will be segregated by meteorology group and by weekday group. The daily maximum ozone-mixing ratio will be plotted as a function of the daily average NOx and ROG in the standard EKMA format. Understanding NOx- and ROG- sensitivity at each station is key to testing the main hypotheses. The purpose is to estimate the extent of NOx and/or ROG limitation on ozone formation at each site and to see if there are significant changes in this between different meteorology groups and weekday groups. Another justification of the EKMA plots is to allow an examination of reactivity changes between the different meteorology and weekday groups. A shift in the ozone contour lines would occur on an EKMA plot if the total reactivity of the ROG mixture changed according to the meteorology or weekday group. Understanding NOx- and ROG- sensitivity at each station is key to testing the main hypotheses.

B9. Estimate the relative age of an air mass from its concentration ratios of reactive to unreactive species. For example, the rate constant for the reaction of HO with benzene is much lower than its rate constant with m-xylene. The concentration ratio of benzene to m-xylene as a function of time (for constant HO) is:

$$[\text{benzene}]_t/[\text{m-xylene}]_t = [\text{benzene}]_o/[\text{m-xylene}]_o * \exp\{(k_1-k_2)*[HO]*t\}$$

where the square brackets represent mixing ratios, o represents the initial condition, t represents time, k_1 is the rate constant for the reaction of HO with benzene and k_2 is the rate constant for the reaction of HO with m-xylene. Since k_1 is less than k_2 the ratio of benzene to m-xylene decreases as a function of time within an air mass. Comparison of concentration ratios of benzene to m-xylene for different air masses will give an estimate of their relative age assuming that the initial concentration ratio is the same. Several different ratios between different ROGs will be required to test the assumption that the initial concentration ratios are the same for the compared air masses. Estimating the plume age at each station for different meteorology groups and by weekday groups will allow characteristic differences between these different groups to be determined. Estimating the plume age at each station is key to testing the main hypotheses.

B10. Characterize the temporal and spatial patterns of total NMHC and NMHC/NOx ratios in the SoCAB during the summers of 1995-1999. For each identified ozone episode that has occurred on weekends during this period, find the timing and location of the peak basin ozone and plot NMHC/NOx ratio, ozone, and DO_3 as a function of sea breeze strength and extent of marine air intrusion. Understanding the relationship among the prevailing west-to-east transport, the timing and magnitude of the peak ozone, and the NMHC/NOx ratios is key to testing the main hypotheses.

Task C - Review of Source Apportionment Analyses (DRI Task 2)

STI and DRI are currently under contract with the South Coast Air Quality Management District (SCAQMD) to analyze the data collected at photochemical assessment monitoring stations in SoCAB during the summers of 1994-97. As part of this work, DRI will apply the Chemical Mass Balance (CMB) receptor model to the PAMS speciated hydrocarbon database.

C1. Review the source apportionment analysis conducted by the Desert Research Institute for SoCAB PAMS data (1994-97) for weekend days and weekdays. Although variations in the relative and absolute source contributions by time of day and day of the week will be examined as part of the SCAQMD project, the expanded examination of air quality and meteorological data that will be undertaken as part of the proposed work for NREL will allow more detailed investigation of the relationship between air quality, meteorology and source contributions.

C2. Review available source composition profiles and identify sources for which updated profiles are needed. We will also evaluate the model performance measures with respect to the magnitude and chemical makeup of the residual unexplained mass and results of Task 1 to identify source composition profiles that are currently missing from the CMB analysis or have large uncertainties associated with the available profiles.

Task D - Analysis of SCOS97-NARSTO Meteorological and 3-D Ozone Data (STI Task 2)

D1. Evaluate meteorological conditions during SCOS97-NARSTO intensive operational periods (IOPs) to determine applicability of each weekend and weekday IOP for assessments of the WE effect.

D2. For applicable IOPs, characterize the surface and aloft spatial and temporal patterns of ozone and ozone precursors utilizing the aloft ozone data measured by LIDAR and instruments on aircraft. Compare the results to 1987 IOPs and determine if the patterns are similar or different. Compare the 1997 weekend and weekday intensive operational periods. Previous analyses of aloft ozone data from SCAQS have shown the presence of deep layers, about 500 m, of high ozone concentrations over a wide portion of the SoCAB (for example, Roberts and Main, 1992). The aloft ozone data collected during SCOS97 using LIDAR and aircraft will be used to evaluate the variability of the characteristics of these aloft ozone layers, and thus evaluate the similarity of the SCOS97 episode days to 1987 episode days, based on the characteristics of the aloft ozone layers. Ozone precursor data collected from aircraft will also be used in the analyses.

D3. Investigate the influence of the mixing heights and wind patterns on ozone concentrations during applicable weekend and weekday IOP days. In studies in several locations across the country, such as the northeastern U.S., Houston, and El Paso, the diurnal profile of the rising mixing height in the morning had a significant influence on maximum ozone concentrations (Dye et al., 1994, 1998; Lindsey et al., 1994; Roberts et al., 1997). Only since the installation of the two PAMS radar wind profilers with RASS (radio acoustic sounding systems) at LAX and Ontario, and during SCOS97, have hourly mixing heights been available for the SoCAB. The radar wind profiler measures, as a function of height, wind speed and direction and the radar signal-to-noise ratio, which can be used to estimate mixing height. The RASS portion of the system measures temperature as a function of altitude, which can also be used to estimate mixing heights. These data will help understand the processes that might influence weekend/weekday differences in ozone concentrations and evaluate the meteorological similarity of weekend and weekday days.

D4. Determine if any of the SCOS97 weekend and weekday IOPs are meteorologically similar in terms of mixing heights, winds, 850 mb temperature, ARB flow type, and synoptic pattern. Develop a matrix of meteorological similarities and differences for the IOP days. Compare the surface and aloft spatial and temporal patterns of ozone and ozone precursors on the IOPs and conceptually quantify the variation in ozone pattern between the weekend and weekday IOP days based on the meteorology.

D5. For applicable IOPs, analyze the data from the SCOS97 upper-air meteorological network and evaluate the regional representativeness of the temporal and spatial variations in wind and mixing heights that can be obtained from the two PAMS profilers (at LAX and Ontario) alone. If LAX and ONT are representative, then LAX and Ontario data can be used for historical and future analysis. If not, then more upper-air monitoring networks may be required in the future to spatial represent the winds and mixing heights. STI will also determine the need for a potential additional upper air measurement between the existing RWP/RASS measurements at LAX and Ontario. In preparation for this proposal, we performed a preliminary comparison of the diurnal mixing heights at LAX and Ontario on two SCOS97 episode days. As expected, both the pattern and the absolute heights at the two sites were different: the mixing height at LAX rose faster in the morning than the mixing height at Ontario. However, by late morning, the mixing height at LAX leveled off and began to slowly decrease, due to the influence of the marine layer while the mixing height at Ontario continued to increase until a 3-4 hour maximum in mid-afternoon. The results at El Monte were different from the results at either LAX or Ontario, although they were more similar to the results at Ontario than those at LAX. This indicates that if the diurnal pattern and the absolute mixing heights are important, then data from LAX and Ontario may not be sufficient for the area in-between, including downtown L.A., Pico Rivera, and Azusa. During this task, we will evaluate this situation using more data from SCOS97 and identify the need for an additional profiler with RASS during the Phase II field study. However, if needed, this is an expensive measurement: approximately $90,000-100,000 for the July-September 2000 period.

Task E - Synthesis of Phase 1 Analyses and Preparation of Phase 1 Report (DRI Task 3 and STI Task 3)

DRI and STI will prepare and deliver a Phase I report summarizing the findings and conclusions of the Phase I analyses. The overall justification for the subtasks within this task is to present our findings to the sponsor and to guide the selection of types and locations of measurements for the field campaign.

E1. Summarize the results of Phase I data analysis. A summary of the conclusions of each main task is presented. The implications of the conclusions for the hypotheses are discussed.

E2. Compare results from each task. The synthesis of conclusions from each task also includes a comparison of findings from related tasks. For example, examination of the time series of pollutants in Task C also provides corroboration of emission inventory results from Task A. The detailed analysis of a few SCOS97 IOP days performed by STI in Task B can be compared to the more general conclusions drawn from many more days during Task C performed by DRI. Insights on mixing heights from the SCOS97 data may be applicable to classes of days treated in the Task C analysis. Tasks A and D also can be cross-correlated.

E3. Update hypotheses. The task results will be used to evaluate the candidate hypotheses. Those hypotheses that are most viable will be retained and those that are least likely to be important will be demoted or dropped altogether.

E4. Revise conceptual model. Based on the new set of hypotheses, a conceptual model of the WE effect will be advanced.

E5. Finalize field measurement program. Based on the Phase 1 task results, DRI and STI will recommend a configuration for the field measurement program to test the revised conceptual model and increase our understanding of the WE effect.

SCHEDULE

A draft report summarizing the results of phase I will be submitted to NREL by March 30, 2000. A final phase I report will follow receipt of comments by approximately one month.

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